



# *Certification of Part 23 Airplanes for Flight in Icing Conditions*

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FAA Small Airplane Directorate

FAA In-Flight Icing International Conference  
Presentation, June 19, 2003



# *Topics*

- ❖ Guidance
- ❖ Regulations
- ❖ Flight Test Safety
- ❖ Web Site
- ❖ Contacts



# *AC 23.1419-2B*

## ❖ Certification of Part 23 Airplanes for Flight in Icing Conditions

➔ NOA published November 20, 2002

➔ Revise/added items

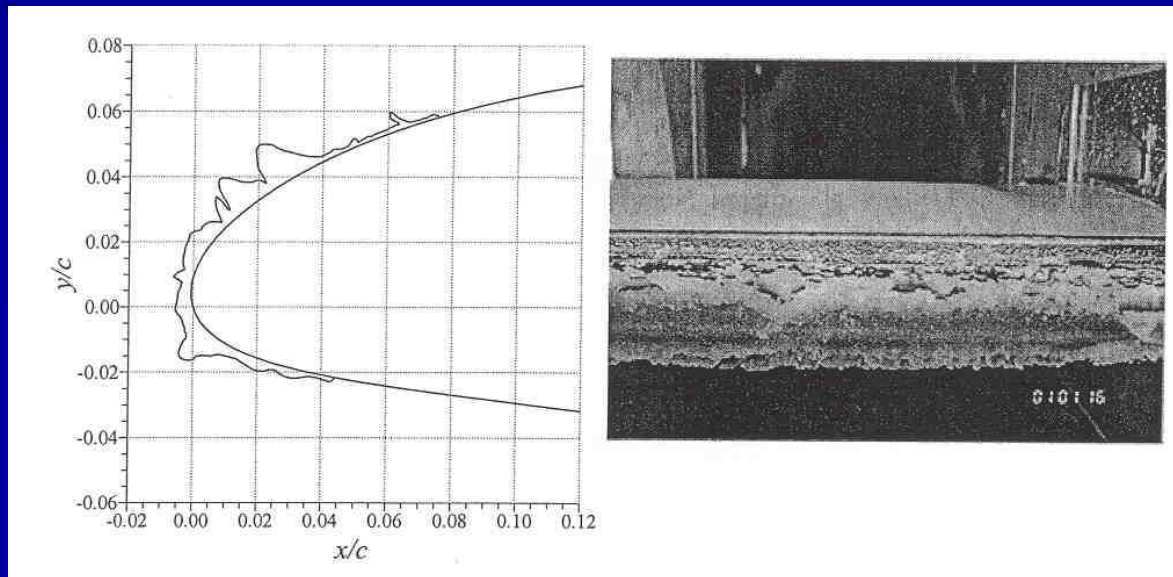
- ◆ Protected surface ice accretion
- ◆ Icing tunnel
- ◆ Autopilot
- ◆ Propeller performance
- ◆ Boot operation
- ◆ Flight test evaluations of installed systems
- ◆ Stall warning



# AC 23.1419-2B

## *Protected Surface Ice Accretion*

- ❖ Intercycle ice
  - ➔ 12 minutes in Continuous Maximum
  - ➔ 14° F, 20  $\mu\text{m}$ , 0.45 g/m<sup>3</sup>, 0° AOA
  - ➔ 3 minute boot cycle





# *AC 23.1419-2B*

## *Protected Surface Ice Accretion*





# *AC 23.1419-2B*

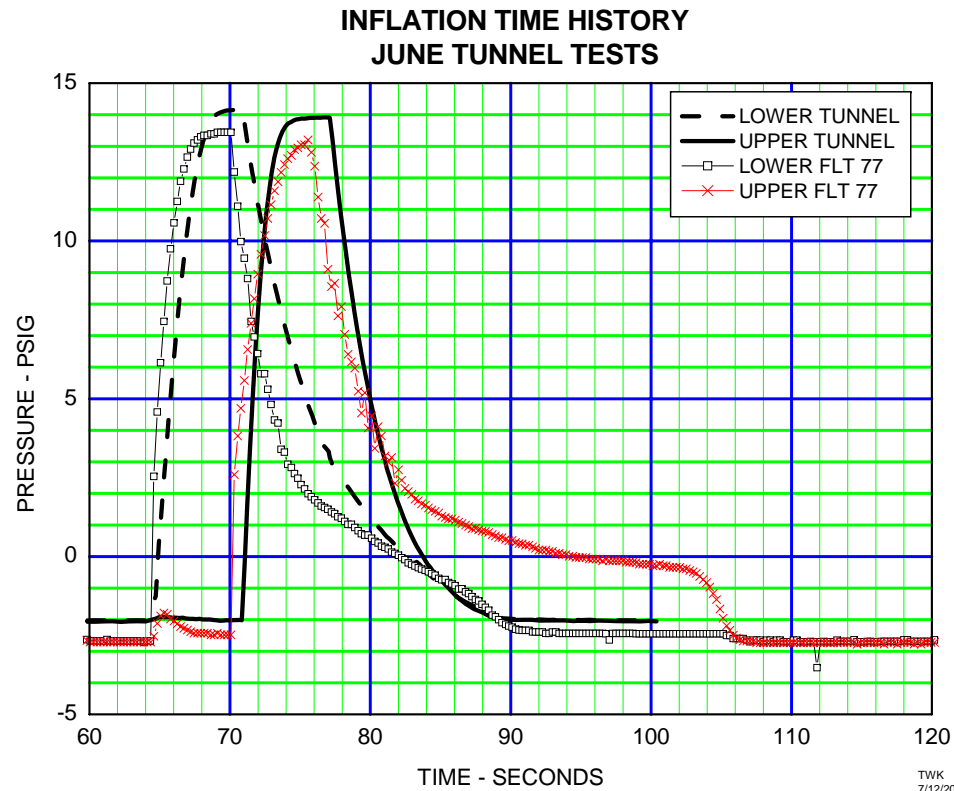
## ❖ Intercycle Ice Flight Test $C_{LMAX}$ Results

Airfoil	Aircraft	Flap	% Loss	$\Delta V$
23012	Part 25	0	25	16
		15	25	16
		45	23	14
23014	Part 23	0	23	10
		20	17	7
NLF 0414	Part 23	0	27	13
		15	23	9
		30	12	4



# AC 23.1419-2B

## *Icing Tunnel*





# *AC 23.1419-2B*

## *Autopilot*







# *AC 23.1419-2B*

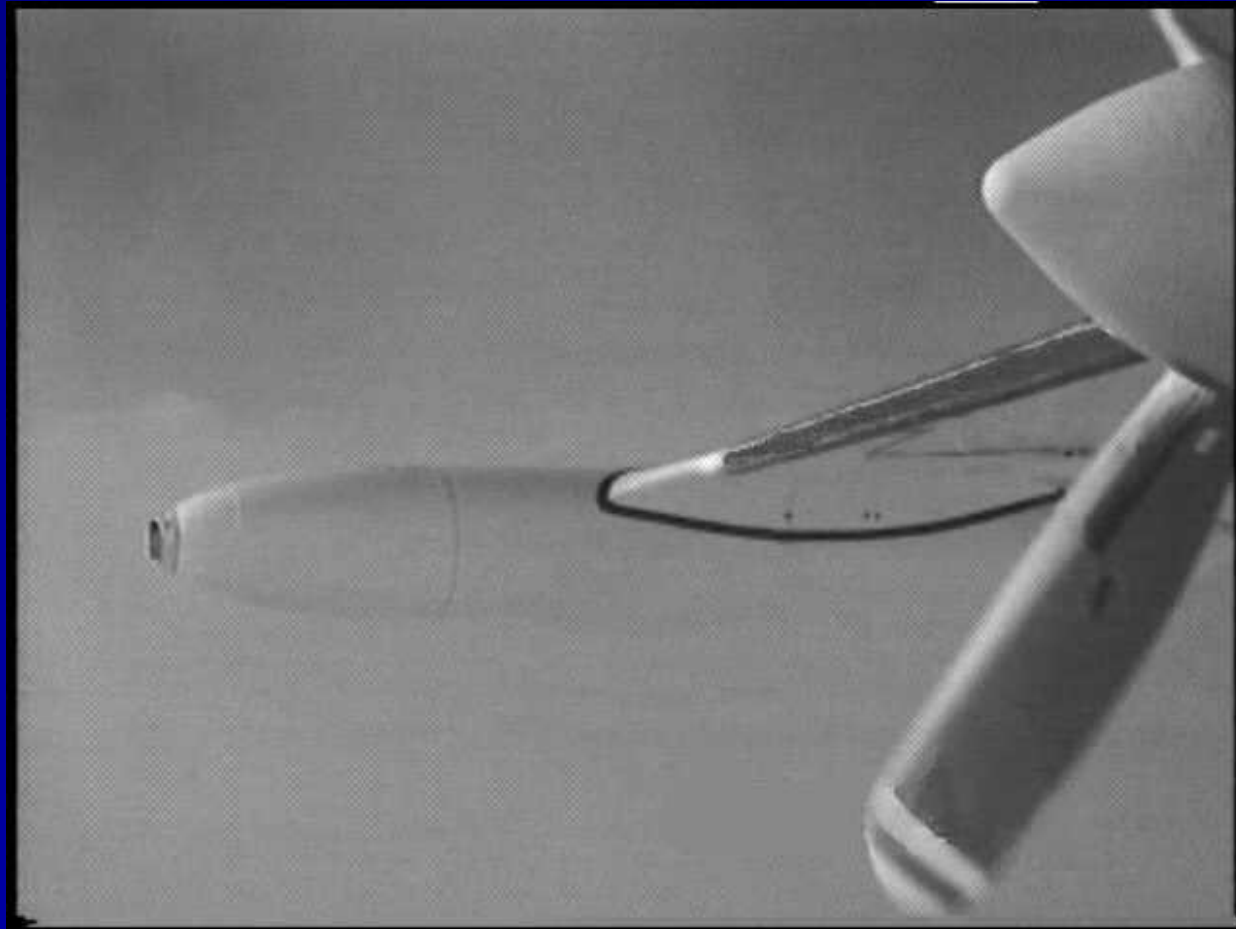
## *Autopilot*

- ❖ All autopilot modes should function properly in icing conditions. The autopilot should be engaged for an extended period of time in natural icing conditions to check for unusual trimming and potential for ice to accrete in control surface gaps “control surface ice bridging.” Appropriate procedures should be added to the AFM.
- ❖ Stall characteristics and adequacy of stall warning should also be evaluated when the airplane is stalled with the autopilot engaged, unless the design of the autopilot precludes its ability to operate beyond stall warning angle of attack. For these designs the controllability of the airplane at autopilot disconnect should be evaluated.



# *AC 23.1419-2B*

## *Propeller Performance*





# AC 23.1419-2B

## *Propeller Performance*

- ❖ Propeller performance within Appendix C also needs to be addressed
  - ➔ Propeller intercycle ice
  - ➔ Propeller runback ice
    - ◆ SAAB 340 operational and flight test experience
    - ◆ Up to 20% propeller efficiency loss
    - ◆ Issue between -5° and -10 ° C
    - ◆ Deice cycle changed from 90/90 to 10/90
    - ◆ Reference: *Experience from a Propeller Icing Certification*, paper presented to SAE AC-9C Aircraft Icing Technology Subcommittee, September 18-22, 1989
  - ➔ Qualitative evaluations in natural icing



# *AC 23.1419-2B*

## *Boot Operation*

- ❖ Many AFMs specify a minimum ice accumulation thickness prior to activation of the deicer boot system
  - “Ice bridging” was the concern
- ❖ Airworthiness Directives issued 1999-2000
  - NTSB recommendation as a result of the January 9, 1997 Monroe Michigan Accident
  - November 1997 FAA/NASA Ice Bridging Workshop
  - October 1998 Letters to Manufacturers
  - February 1999 Inflight Operations in Icing Conference



# AC 23.1419-2B

## *Boot Operation*

- ❖ Flight testing and icing tunnel testing of “modern” boots showed ice bridging is not an issue.
- ❖ The recommended AFM procedure for boot operation should be to operate the boots in an appropriate continuous mode at the first sign of ice and not to wait for a specific amount of ice to accumulate.
- ❖ Recent certifications:
  - Determining a specific ice accretion thickness is difficult
    - ◆ Adopted AFM boot activation at first sign of ice accretion
  - Manual boot operation results in high workload
    - ◆ Adopted timer for automatic boot cycles
  - 3 minute boot cycle mode results in large intercycle ice accretion and determining whether to use 1 or 3 minute mode adds to workload
    - ◆ 3 minute mode removed (also AD on EMB-120)



# AC 23.1419-2B

## *Flight Test Evaluations*





# *AC 23.1419-2B*

## *Stall Warning*

- ❖ Stall warning in icing conditions
  - ✈ Should be same margin as in non-icing conditions
  - ✈ Type of stall warning should be the same
- ❖ Maneuver margin
  - ✈ Coordinated turns and 30/30 rolls



# *AC 23.1419-2B*

## Other guidance

- 61 knot stall speed exemption
  - ◆ 23.1419 Amdt. 23-43 requires airplane performance in icing to comply with Subpart B
- Subpart B testing
- Ice adhesion inhibitors
- Replacement boot policy





## *AC 23.1419-2C*

- ❖ Small Airplane Directorate Mega ACs on 2 year revision cycle
- ❖ FAA internal review starting June 30, 2003
- ❖ Out for public comment by December 30, 2003



# AC 23.1419-2C

## ❖ Additions:

- STC and Amended TC on airplanes certificated for flight in icing conditions
  - ◆ Engine changes
  - ◆ Propeller changes
  - ◆ Antennae installations
  - ◆ GW/CG envelope increase
- Non-hazard installations
- Certification basis
- Subpart B testing
  - ◆ Based on proposed FTHWG guidance
- Roll control in SLD
- Flight test tolerances



# *AC 23.1419-2C*

## ❖ Additions:

- Pitot and stall warning heat
- Primary ice detector
- Instructions for Continued Airworthiness
  - ◆ Pneumatic boot repair procedures
  - ◆ Electrothermal boot repair procedures



# AC 23.143-1

## ❖ Ice Contaminated Tailplane Stall (ICTS)

➔ NOA published February 1, 2002

◆ Prior to that date July 12, 1994 SAD Policy Memorandum

➔ Unchanged items

◆ Maneuvers

◆ Test conditions

◆ Pass/fail criteria

➔ Revised/added items

◆ Clarification of ice accretions to be tested

\* Critical, 40 grit sandpaper, failure

◆ Landing flap position may be reduced

\* Should AFM procedures be based on ice accretion or OAT/visible moisture?

◆ Factors affecting ICTS susceptibility

◆ Flight test risk mitigation procedures



# AC 23-17A

- ❖ Systems and Equipment Guide for Certification of Part 23 Airplanes
  - NOA published September 17, 2002
  - 23.1326 Amdt. 23-49 requires annunciation when pitot heat fails or is switched “off”
    - ◆ Based on NTSB recommendation A-92-85 and investigation of fatal accidents (NTSB/SIR-92/03)
    - ◆ AC states an Equivalent Level of Safety finding will be accepted if there is information in a placard or flight manual about when to operate the pitot heat.
  - Issue surfaced on recent certification program
    - ◆ ELOS offered in AC is appropriate for airplanes where operations minimize pitot icing exposure
      - \* Not certified for IFR or icing
      - \* If IFR not capable of higher altitudes



# AC 23-16

## ❖ SAD Policy Statement ACE-01-1093(b)

➔ NOA published November 7, 2001

➔ Guidance in:

- ◆ Use of similarity and service experience
- ◆ Use of tunnel test data
- ◆ Falling/blowing snow requirement
- ◆ Ground ice fog requirement

➔ Will be incorporated into revision to AC 23-16

- ◆ Public comment period September, 2003



# *Regulations*

- ❖ Part 23 Wish List for 23.1419:
  - “If certification with ice protection provisions is desired...”
  - Modify required Subpart B requirements
    - ◆ Change “Performance” to “Climb Performance”
    - ◆ Add stall warning
  - Delete 23.1416 and add requirement for IPS failure annunciation
  - Add proposed 25.1419 regulations on ice detection and IPS operation
    - ◆ Ice detector would not be required
- ❖ Incorporate proposed 25.1420 regulation
  - Modified for Part 23



# *Flight Test Safety*

- ❖ FAA Order 4040.26A
  - ✈ Ice shape testing HIGH risk
  - ✈ Natural icing MEDIUM risk (may be HIGH)
  - ✈ Tanker testing MEDIUM risk





# *Flight Test Safety*

## Risk Assessments

- ✈ Departure from controlled flight
- ✈ Engine flameout/ propeller malfunction
- ✈ General

### ❖ Examples at:

- ✈ [www.faa.gov/certification/aircraft/](http://www.faa.gov/certification/aircraft/)
- ✈ [small\\_airplanes\\_ice\\_testing.htm](http://www.faa.gov/certification/aircraft/small_airplanes_ice_testing.htm)



# *Wing Underside Ice*





# ❖ Small Airplane Directorate on the FAA Internet



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**1. What are the types of "small airplanes" and the different design characteristics?**

The following table describes the types of small airplanes and their design characteristics

**Small Airplane Types and Design Characteristics**

Airplane Type	Design Characteristics
<a href="#">Normal, Utility, &amp; Acrobatic Category</a>	<ul style="list-style-type: none"><li>• maximum takeoff weight of 12,500 lbs</li><li>• maximum passenger seating capacity of 9</li></ul>
<a href="#">Commuter Category</a>	<ul style="list-style-type: none"><li>• maximum takeoff weight of 19,000 lbs</li><li>• maximum passenger seating capacity of 19</li><li>• multiple engines</li><li>• propeller driven</li></ul>

The screenshot shows a web browser window with the FAA website. The browser's address bar and toolbar are visible at the top. The website header features the FAA logo and navigation links: Home, Site Map, DOT, Ask FAA, Search, and Employment. On the left, a blue sidebar contains the 'Aircraft Certification Menu' with links to Advisory Circulars (ACs), AD NPRMs, Airworthiness Directives (ADs), Regulatory Basis, Employment Information, Federal Aviation Regulation (14 CFR), Forms, and Notices. The main content area displays a list of links and questions. The first link is '14 CFR Part 43 - MAINTENANCE, PREVENTIVE MAINTENANCE, REBUILDING, AND ALTERATION'. Below it is question 5: 'What are the operational requirements applicable to Normal, Utility, & Acrobatic Category airplanes?'. This is followed by two more links: '14 CFR Part 91 - GENERAL OPERATING AND FLIGHT RULES' and '14 CFR Part 135 - OPERATING REQUIREMENTS: COMMUTER AND ON-DEMAND OPERATIONS AND RULES GOVERNING PERSONS ON BOARD SUCH AIRCRAFT'. Then comes question 6: 'Can you provide me with a comparison between CAR 3 and Part 23 ?'. Question 7 asks: 'How about some frequently asked questions ?'. Below the questions, a text prompt says 'I would like more specific type certification information related', followed by a list of links: 'Airplane/Crew Flight Test & Performance', 'Airframe Structure', 'Systems & Equipment', 'Powerplant Installation', 'Passenger & Cargo Layout, Interiors, & Cabin Safety', 'Flammability & Fire Protection', 'Ice Protection', 'Lightning Protection', 'Manuals, Instructions, Limits, Placards, & Markings', and 'Noise'.

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- [14 CFR Part 43](#) - MAINTENANCE, PREVENTIVE MAINTENANCE, REBUILDING, AND ALTERATION

5. What are the operational requirements applicable to Normal, Utility, & Acrobatic Category airplanes?

- [14 CFR Part 91](#) - GENERAL OPERATING AND FLIGHT RULES
- [14 CFR Part 135](#) - OPERATING REQUIREMENTS: COMMUTER AND ON-DEMAND OPERATIONS AND RULES GOVERNING PERSONS ON BOARD SUCH AIRCRAFT

6. Can you provide me with a [comparison between CAR 3 and Part 23](#) ?

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## Aircraft Certification Products and Services Normal, Utility, & Acrobatic Category Ice Protection

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### 1. What Part 23 requirements and associated policy & guidance apply to Airplane Ice Protection?

The following link provides information on part 23 requirements and associated policy & guidance which apply to airplane ice protection:

- [Advisory Material, Policy, & Guidance](#)
- [Requirements \(FARs\) with associated advisory material, policy, & guidance](#)

### 2. What Other Reference Material do you have pertaining to Part 23 Icing Certification?

The following link provides Other Reference Material pertaining to Part 23 Icing Certification:

- [Other Reference Information](#)

### 3. Where can I find some Frequently Asked Questions and Answers pertaining to Part 23 Icing Certification?

Below is a link to some frequently asked questions concerning Part 23 Icing Certification:

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<a href="#">23.1357</a>	Circuit protective devices.	( <a href="#">pdf</a> ), "Icing Policy for Small Airplanes" dated Feb 6, 1998
<a href="#">23.1416</a>	[Pneumatic de-icer boot system.]	<ul style="list-style-type: none"> <li>• SAD memorandum ( <a href="#">text</a> ) ( <a href="#">pdf</a> ), "Icing Policy for Small Airplanes" dated Feb 6, 1998</li> </ul>
<a href="#">23.1419</a>	Ice protection.	<ul style="list-style-type: none"> <li>• <a href="#">AC 20-73</a></li> <li>• <a href="#">AC 20-117</a></li> <li>• <a href="#">AC 23.1419-2B</a></li> <li>• <a href="#">AC 23-17A</a> , Section 23.1419</li> <li>• SAD memorandum ( <a href="#">text</a> ) ( <a href="#">pdf</a> ), "Icing Policy for Small Airplanes" dated Feb 6, 1998</li> </ul>
<a href="#">23.1431</a>	Electronic equipment.	<ul style="list-style-type: none"> <li>• AC 23-8B, paragraph 350</li> <li>• <a href="#">AC 23-15</a> , paragraph 4.v</li> <li>• <a href="#">AC 23-17A</a> , Section 23.1431</li> </ul>
<a href="#">23.1501</a>	General.	<ul style="list-style-type: none"> <li>• AC 23-8B, paragraph 365</li> <li>• SAD memorandum ( <a href="#">text</a> ) ( <a href="#">pdf</a> ), "Icing Policy for Small Airplanes" dated Feb 6, 1998</li> </ul>

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[Ice Protection Advisory Material, Policy, & Guidance](#)

[Small Airplane Certification Process](#)

[Part 23/CAR3 Comparison](#)

**1. Where can I find more reference information pertaining to Small Airplanes Ice Protection?**

You can find more reference information pertaining to Small Airplanes Ice Protection through the following links.

- [FAA Documents](#)
- [SAE Documents](#)
- [Miscellaneous Documents](#)
- [Icing websites](#)
- [Information related to testing](#)

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Small Airplane Directorate, ACE-100  
201 Locust, Room 201





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You may order the following SAE Documents from the Society of Automotive Engineers:

- Aerospace Recommended Practice (ARP) 4761 "Guidelines and Methods for Conducting the Safety Assessment Process on Civil Airborne Systems and Equipment"
- Aerospace Information Report (AIR) 4367 "Aircraft Ice Detectors and Icing Rate Measuring Instruments"
- Aerospace Information Report (AIR) 5504 "Aircraft Inflight Icing Terminology"
- Aerospace Standard (AS) 5116 Rev. A "Minimum Operational Performance Specification for Ground Ice Detection Systems"

### 2. What SAE Documents are being developed and will soon be available from the SAE?

The SAE and a working group for Task 11A of the FAA Inflight Aircraft Icing Plan are developing the following documents and will be available soon from the SAE:

- Aerospace Recommended Practice (ARP) 5903 "Droplet Impingement and Ice Accretion Computer Codes"
- Aerospace Recommended Practice (ARP) 5904 "Airborne Icing Tankers"
- Aerospace Recommended Practice (ARP) 5905 "Calibration and Acceptance of Icing Wind Tunnels"

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#### 1. Do you have a listing of Icing Related Websites?

The following is a list of Icing Related Websites:

- [FAA Technical Center](#)
- [NASA Glenn Icing Research](#)
- [University of Illinois Aircraft Icing Research Group](#)

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#### For further information, please contact:

Federal Aviation Administration  
Small Airplane Directorate, ACE-100  
901 Locust, Room 301  
Kansas City, MO 64106



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◆ MKC-AEG (816) 329-3238



❖ Now a slightly different but related subject



# *Lessons Learned from Flight Testing Stall Characteristics of Large Turbopropeller Airplanes*

- ❖ Large sideslip excursions are possible
  - No sideslip gage
  - Power on
  - Left turns
  - Low true airspeed
- ❖ Attempting to correct using ball may result in excitation of Dutch roll
- ❖ Power application at high angle of attack
  - Pitch up
  - Left roll
- ❖ Autopilot disengagement at high angle of attack
  - Large push force for recovery





## *Recommendations for Certification Testing*

- ❖ Fly ball, not sideslip gage when conducting stalls
  - Provide gage for pilots
  - Provide real time sideslip for test team
  - Establish recovery limits
- ❖ Include stall approaches at low AOA rate
  - Flat lift curve
  - Anticipation logic
  - Time for sideslip to build
- ❖ Thrust is critical
  - Define power required at  $1.6 V_S$  icing
  - Include low weight test points



## *Recommendations for Certification Testing*

- ❖ Make sure ice accretions on vertical tail and dorsal are accounted for
- ❖ Evaluate recoveries at stall warning with power only
- ❖ Evaluate adequacy of stall warning margin with autopilot engaged
- ❖ Stall protection system tolerances need to be accounted for



## *Recommendations for Training*

- ❖ Aerodynamic model
  - Effect of sideslip on stall angle of attack
- ❖ Flight test maneuvers for simulation validation:
  - Effect of sideslip on production AOA calibrations
  - Production sideslip calibration
  - Lateral/directional aerodynamic coefficients at high angle of attack with power off and on
  - Pedal free stall approach